IPHWG Task 1 Part 25 Rule Report for TAEIG
June 1, 2001

REPORT OBJECTIVE

This report is submitted to TAEIG in response to an IPHWG task to review a proposed Part 25 certification rule intended to address the certification aspects of Task 1. This proposed rule was drafted by the FAA with harmonization by the JAA prior to IPHWG review. The IPHWG was given one meeting for this review in order to formulate comments and concerns. Consensus was not an objective. The purpose of this report is to document these IPHWG member comments and concerns to the rule as proposed.

TASK STATEMENT

As the IPHWG Tasks 1 and 2 are the basis of much of the discussion on the proposed rule, the tasking language is provided for reference.

> Task 1. As a short-term project, consider the need for a regulation that requires installation of ice detectors, aerodynamic performance monitors, or another acceptable means to warn flightcrews of ice accumulation on critical surfaces requiring crew action (regardless of whether the icing conditions are inside or outside of Appendix C of 14 CFR Part 25). Also consider the need for a Technical Standard Order for design and/or minimum performance specifications for an ice detector and aerodynamic performance monitors. Develop the appropriate regulation and applicable standards and advisory material if a consensus on the need for such devices is reached.
>
> Task 2. Review National Transportation Safety Board recommendations A-96-54, A-96-56, and A-96-58, and advances in ice protection state-of-the-art. In light of this review, define an icing environment that includes supercooled large droplets (SLD), and devise requirements to assess the ability of aircraft to safely operate either for the period of time to exit or to operate without restriction in SLD aloft, in SLD at or near the surface, and in mixed-phase conditions if such conditions are determined to be more hazardous than the liquid phase icing environment containing supercooled water droplets. Consider the effects of icing requirement changes on 14 CFR Part 25 and revise the regulations if necessary. In addition, consider the need for a regulation that requires installation of a means to discriminate between conditions within and outside the certification envelope.

Task 1 was partially addressed by the development of a Part 121 Operations rule and Advisory Circular proposal. This work has been completed by the IPHWG and submitted to TAEIG 2-Mar-01 for transmittal to the FAA. Task 2 is still in work at the IPHWG level. A report on the challenges of Task 2 was submitted to TAEIG on 14-Feb-01. The proposed certification rules addressed in this report are intended to complete the IPHWG Task 1 requirements.

PROPOSED §25.1419 REVISIONS

The proposed revisions to §25.1419 would require either the installation of a primary ice detection system; or the definition of visual cues for recognition of ice accretion on a specified surface, combined with an advisory ice detector that provides an alert; or the identification of conditions conducive to airframe icing through the use of temperature and visible moisture cues. The requirements of the proposed rule are very similar to that previously proposed for the Part 121 operations rule. The IPHWG reviewed the proposed §25.1419 with minor changes made during the meeting. No other objections were made to this proposal. The IPHWG recommends that TAEIG transmit the proposed rule changes to §25.1419 to the FAA for processing as an NPRM with TAEIG approval.

PROPOSED §25.1420 ADDITION

The proposed addition of §25.1420 as prepared by the FAA and contained in the NPRM draft (which this report addresses) would require aircraft with reversible flight controls in the pitch or roll axis to have a method to indicate to the flightcrew that the airplane is in conditions conducive to ice accumulation aft of the airframe's protected areas. The proposal would require that such conditions be exited when encountered. During IPHWG deliberations, concerns were expressed regarding the proposed addition of §25.1420. The discussions centered on the discriminator that determines the applicability of the rule and the timing of the rule in relation to Task 2 deliverables.

The discriminator of unpowered flight controls was used in the previously submitted IPHWG Part 121 Operations Rule proposal. However, its applicability if used in a certification rule would be much different. The Operations Rule proposal was developed to apply to existing airplanes with known control system design features and flight characteristics, and for which a wealth of operational history is available. For reasons which are set forth and explained in the Operations Rule proposal, it was limited to airplanes in Part 121 revenue service. Inserting this discriminator into a Part 25 Certification Rule would make it applicable to all new designs of presently unknown control system design features and flight characteristics, and regardless of their intended types of operation. It could have the unintended consequence of driving manufacturers to employ complicated and expensive powered flight control systems on airplanes which don't need them.

The relationship with Task 2 lies in the definition of the large droplet icing environment and the ability to assess that an aircraft is capable of safely operating in these conditions for the period to exit or to operate without restriction.

The IPHWG identified three options for the proposed §25.1420. Option A would accept the rule language as proposed for the time being, with the intent of revisiting it as progress is made on Task 2. Option B would remove the discriminator of unpowered flight controls, but would allow the manufacturer to demonstrate that exiting the conditions is not required. Option C would delay the release of the proposed §25.1420 until further progress is made towards Task 2. These options are described in detail with the applicable rational analysis in the following sections.

OPTION A

Option A would accept the rule language as proposed. The rule as written would require all aircraft with reversible roll or pitch controls to provide a means for the flight crew to determine that the aircraft is in conditions conducive to ice accumulation aft of the airframe's protected areas and establish procedures for exiting the icing conditions. No options other than exiting the conditions are permitted under this proposal. As written, this rule captures the existing class of aircraft that are dominant in the safety record as discussed in the proposed preamble materials.

The rule as drafted does not address any requirements for safely exiting the conditions or requirements for aircraft with other than reversible flight controls.

It is restrictive in that there are no alternatives to exiting the conditions. This burden was the impetus to applying the reversible flight control discriminator in the Operations Rule proposal to limit the applicability to aircraft that might be susceptible to roll and pitch deviations and to implicitly exclude types not susceptible due to their size and design features and as verified by their absence from the event database. However, there are also aircraft with reversible pitch or roll axis flight controls which have no accident and incident history in the database. This proposed rule could be a significant burden on new certifications of these types of aircraft. There is a need to define a criterion that would allow aircraft to safely operate for the time required to exit or to operate unrestricted in such an environment and minimize the requirement to exit the conditions.

There currently are no accepted engineering standards to define the large droplet conditions or to evaluate the effects of these conditions on an aircraft. The ability to show that an aircraft can be operated safety in conditions outside of Appendix C is largely dependent the completion of Task 2. Given the definition of an icing environment as required by Task 2, additional factors are required to adequately assess the capability of aircraft to operate in these conditions. The engineering tools to simulate the ice accretions formed from these clouds are required as well as definitions of acceptable performance degradations with the large droplet accretions. The Flight Test Harmonization Working Group has proposed rule changes to define acceptable flight characteristics in icing conditions. It is expected that these proposed rules will be used in defining acceptable standards for large droplets. However, the acceptability of these standards for large droplet accretions requires review. Given the infrequency of the encounter and the potential severity of the effects on small Part 25 aircraft, consideration of alternate criterion such as "safe return and landing" may be appropriate. The issues surrounding the completion and challenges of Task 2 were discussed in detail in the IPHWG Task 2 report as presented to TAEIG.

As there is no engineering standard for large droplet icing, no validated methods of simulation and no performance criterion to evaluate whether an aircraft is capable of safely operating in the conditions, the best "short-term" alternative (as required by Task 1) may be to require an exit from the conditions until more progress as made. The proposal as written could accomplish this. As part of this option, Task 2 could be revised to reconsider the rulemaking language in the proposed 25.1420 when the ability to assess whether an aircraft can operate in this environment is more mature. This option provides a balance in what can be achieved in a short-term task without unduly restricting all Part 25 aircraft from exiting large droplet conditions or imposing overly conservative test methods that will penalize small Part 25 aircraft. However, there is a burden on possible new types of aircraft with reversible roll or pitch flight controls which may not be susceptible to controllability hazards in large droplet conditions. These aircraft will still be required to exit the large droplet icing conditions.

Another concern was discussed regarding the use of the reversible flight controls as a discriminator. The concern is that the proposed rule would not directly address performance-based effects of large droplet accretions. While a direct means to address this concern is not apparent, the concern is addressed to a significant degree. The design choice of using irreversible flight controls is a function of the aerodynamic loads on the control surfaces. These loads are typically a function of aircraft speed envelope and/or of aircraft scale. Large-scale aircraft are less susceptible to all icing conditions due to the reduced collection efficiency of the airfoils. High-speed aircraft typically have significant power margin when operating at low altitude holding speeds where the large droplets would likely be encountered. Because of these design factors, small scale and low speed aircraft that could be susceptible to performance-based effects are included implicitly with the reversible flight control discriminator.

OPTION B

This option would be to eliminate reversible controls discriminator and make the FAR 25.1420 proposal applicable to all new Part 25 certifications, but would allow demonstration that exiting the conditions is not required. The major difficulty with this option is that there is no existing means of compliance with such a no exit provision. The FAA concern is that the large droplet conditions would have to be defined to release the rule in this state, and this requires the completion of IPHWG Task 2.

Three members commented on the substance of Section 25.1420. All recommended to eliminate the reversible flight control discriminator and to allow demonstration that exiting the conditions is not required. The commenting members expressed a number of concerns, the foremost of which is that the rule as currently written is focused on one specific type of event involving uncontrollable hinge-moment characteristics. While this is a valid and well-documented scenario, the proposed rule does not address potential performance degradations (lift loss and/or drag increase) which may be associated with large droplet ice accretions. The effects of large droplet ice accretions on performance characteristics will manifest on any airplane, regardless of the type of flight controls. The database examined by the group contains 48 events in which the IPS was activated prior to the event; 11 of these contained evidence of large droplet icing conditions. Yet, of the 48, only 3 involved tailplane flow separation and only 1 accident was due to increased hinge moments causing loss of lateral control with large droplet ice accretion. The rule ignores the remaining large droplet icing events, the causes of which are either unknown or in some cases can be surmised to have been loss of performance. In addition, the members noted concerns related to unaccounted-for runback in large droplet conditions (another performance-degradation aspect); the potentially significant degradation of propeller performance with large droplet ice accretion; and the fact that this certification rule for future aircraft targets a current design feature, presupposing how future designs will perform with large droplet ice accretions.

The commenting members do not believe that either completion of Task 2 or a concretely established definition of large droplet icing conditions is required to allow demonstration that exiting large droplet conditions is not necessary. While the question of how to show that an airplane need not exit large droplet icing conditions was approached somewhat differently by each member within the context of the rule and associated AC material, they all proposed rule language allowing a manufacturer to do so. These members are of the opinion that currently available tools and methods, along with conservative engineering judgment, can be employed for this purpose until improved methods are developed. One method proposed was to use the icing cloud physics as described in the FAA Generic Issue Paper published July 23, 1997 as a starting point for defining an SLD environment for the purposes of this rule.

There are objections to this approach, however. Previous work on this issue has used rudimentary approximations of the large droplet icing conditions. As a result of the ATR 72 icing accident in 1994, an investigation of the effects of potential large droplet conditions was performed on regularly scheduled revenue passenger service aircraft in the United States. These investigations used approximations of the environment thought to have been present in the accident situation. These investigations relied on the use of the 1" quarter round (facing forward behind the protected area) and the use of a tanker aircraft with approximated large droplet conditions. The duration used was the approximate time the accident aircraft was in the conditions prior to the event, not the time required to exit the conditions. The icing environment in terms of water content, drop size and distribution were an estimate, as was the duration of the encounter. No sampling of the actual icing environment in terms of droplet size and distribution was available. The estimates were specific to the accident and do not account for SLD variations in the atmosphere. These conditions were intended to provide a conservative test of the susceptibility of certain aircraft to large droplet conditions. There was no intent to show safe operation in the large droplet environment. This type of first-order approximation is appropriate for a safety investigation, but does not represent the long-term solution that should be the objective of rulemaking.

It is generally accepted that the aerodynamic effects of ice accretions on an airfoil are largely a function of location and the relative size of the disturbance. Part 25 rulemaking covers aircraft ranging from 12,500 lbs up to aircraft in excess of 800,000 lbs. Given this broad range of aircraft, an overly conservative approach to large droplet icing (such as 1" quarter rounds) may not have a significant effect on large Part 25 aircraft, but can have a severe effect on small Part 25 aircraft. The actual size of accretions that can form behind the protected area is a function of the protection limits, the airfoil type and planform characteristics (e.g. taper ratio, thickness ratio, washout).

While a conservative method of screening aircraft is desired, if the methods are overly conservative, smaller Part 25 aircraft with unpowered flight controls could be excluded from future certification in large droplet icing conditions for the period required to exit. It may not be feasible or even technically possible to design small Part 25 aircraft for extended operations in all large droplet-icing conditions with a large degree of conservatism. The safety record for small Part 25 aircraft (such as business jets) indicates that a measure this far reaching may not be warranted.

OPTION C

This option would delay the release of the proposed §25.1420 until further progress is made towards Task 2. The rule could then be written to eliminate the reversible pitch or roll control discriminator and would require a demonstration of the ability of an aircraft to operate safely in the large droplet conditions either for the time required to exit or for continued operation in such conditions.

For the period until Task 2 matures, an increased level of safety would be maintained by the adoption of the IPHWG proposed Part 121 Operations rule. The Part 121 rule is applicable to aircraft less than 60,000 lbs. with reversible pitch or roll flight controls. The draft language in the Part 121 rule would require an exit from conditions conducive to ice accumulation behind the aircraft's protected area. This rule will provide an enhanced level of safety for the traveling public until a more complete approach to large droplet icing is feasible.

Motivation for this option is the lack of agreed upon icing physics definitions for large droplet clouds, the immature state of the simulation and validation tools and the lack of an engineering standard to evaluate the handling quality and performance decrements against.

The susceptibility of an aircraft to ice accumulation effects aft of the protected areas is a combination of many aspects of aircraft design. Airfoil sensitivity, sweep angle, airfoil loading, chord lengths, flap effectiveness, the use of trimmable stabilizers, alternate roll control means (such as roll spoilers) as well as the use of reversible flight controls are all generally accepted factors that can contribute to or reduce the susceptibility to pitch or roll events due to ice accumulations aft of the protected areas. As discussed briefly in option A, the use of reversible flight controls as the sole discriminator will penalize a large category of Part 25 aircraft that have not exhibited an accident or incident history that would indicate a safety issue. Option C accomplishes the majority of the Task 1 directive without penalizing aircraft with reversible pitch or roll controls that are not adversely affected by large droplet icing.

Specifically, many business aircraft use reversible flight controls with no indications of susceptibility to ice accumulation aft of the protected areas. Many of these aircraft use reversible flight controls on both the roll and the pitch axis in conjunction with various combinations of de-ice and anti-ice methods including pneumatic de-ice boots, bleed air, electro-thermal, and TKS systems. Many of the aircraft use running wet thermal systems. These aircraft have been certified with significant amounts of runback ice accumulation behind the protected areas. While runback ice is not identical to ice accretions as the result of large droplet impingement, this certification evaluation ensures reduced sensitivity to contamination behind the protected areas.

As discussed briefly in Option A, to show that no crew action is required to exit the conditions requires some means to evaluate the aerodynamic effects of such accretions. Currently accepted techniques of accomplishing this is with simulated ice shapes. The effects of these simulated ice shapes are evaluated with wind tunnel testing or by flight-testing. For Appendix C icing conditions, the ice shapes are generally defined using analytical techniques (such as LEWICE), by icing tunnel testing using droplet sizes and water contents as defined by Appendix C or by icing tanker testing. In order to evaluate the effect of large droplet accretions a definition of the icing environment is required. This definition must define droplet size and distribution, water content and horizontal extent. Initial indications are that the distribution has a significant effect on large droplet accretions, which differs from Appendix C icing. It has generally been shown that monotonic distributions provide near equivalent ice shapes within Appendix C conditions. Indications from analyses such as published in AIAA 98-0487 (Anil Shah, et.al.) are that droplet distribution will have a significant effect on the shape characteristics of large droplet accretions, particularly in the aft most impingement regions. Actual measured distributions have a significant proportion of small droplets in combinations with the large droplets. Assuming that SLD distributions consist entirely of larger sized drops (Langmuir type distributions) will artificially increase the collection efficiency (due to the direct relationship between drop size and collection efficiency) in the aft most regions. The aft most accretion regions are of particular significance as they are likely to be the regions immediately behind the protected areas. With initial indications of impingement limits ranging back to 50% of the chord length, it may be impractical to protect against all large droplet accretions. The ability to simulate accretions behind protected regions will be essential in the certification of large droplet conditions.

In addition to the lack of definition of the icing environment, there are also shortfalls in the technology available to simulate a large droplet condition. Analytical simulation techniques such as LEWICE have not been validated for large droplet icing environments. Research is underway to examine some of the known effects such as splashing, droplet breakup and gravitational effects. However there are challenges in these methods such as the ability to simulate distributions with a wide range of droplet sizes and the limited plume size available in horizontal icing tunnels. Further work and funding has been planned for these areas, but is still a minimum of 2-3 years away.

It is not reasonable to expect that the large droplet engineering tools need to reach the same state of maturity that current Appendix C tools are at prior to future rulemaking. Task 2 includes language that directs the regulations to be revised as required. Appropriate advisory materials would need to be drafted to provide guidance on an acceptable means of compliance. Releasing a rule with no guidance on compliance methods will place an undue burden on both the manufacturers and the local Aircraft Certification Offices when finding compliance on the rule. It is not feasible to release rules with no known means of compliance. This would negate any benefit of using the ARAC process to consider these issues.

Delaying the release of proposed §25.1420 until further progress is made on Task 2 would allow the rule to be drafted in a manner that would eliminate the reversible pitch or roll control discriminator. This option would require a demonstration of the ability of an aircraft to operate safely in the large droplet conditions either for the time required to exit or for continued operation in such conditions. This method would also address member concerns regarding the exclusion of potential performance effects due to large droplet accretions and would require all Part 25 aircraft to be evaluated for potential adverse affects of large droplet conditions. As previously stated, the Task 1 requirements would be met with the proposed Part 121 operations rule for regularly scheduled air carriers. This would provide an enhanced level of safety for the interim period.

CONCLUSIONS AND RECOMMENDATIONS

The proposed rulemaking was deliberated at length during the IPHWG review. In addition, formal comments were solicited from IPHWG membership on specific points of recommendation. Some of the comments were resolved without issue, while others were recommended to be included in the IPHWG report for further consideration by the authorities during the rulemaking process. These specific comments are included in Appendix A. With regard to the proposed changes to §25.1420, there were strong supporters for each of the options presented. Multiple technical factors both add and detract from each of the options. Many of the factors presented under each individual option can be equally applied to support or diminish alternate options. No clear majority opinion could be achieved during the review period. The technical factors supporting each of the options are as presented in the body of this report. It is recommended that the FAA and JAA consider these factors, as presented, for future rulemaking proposals on this topic.

Appendix A

Comments Received through IPHWG Review Process

Comment # 1

Document, Section Title & Paragraph (ex: NPRM, 5. Technology, 2nd Paragraph)
Cert Rule NPRM

Existing Text (excerpt, page, etc.)

§ 25.1420 Exit large droplet conditions.

(a) For airplanes with reversible roll or pitch controls: if certification for flight in icing conditions is desired, one of the following must be provided to alert the flightcrew that they must exit icing conditions

(1) Substantiated visual cues that enable the flightcrew to determine that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas; or

(2) A system that alerts the flightcrew that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas.

(b) Procedures for exiting icing conditions must be established.

Proposed Text Language

§ 25.1420 Exit large droplet conditions for airplanes with reversible controls.

For airplanes with reversible roll or pitch controls where certification for flight in icing conditions is desired in 25.1419,

(a) one of the following must be provided to alert the flightcrew that they must exit icing conditions :

(1) Substantiated visual cues that enable the flightcrew to determine that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas; or

(2) A system that alerts the flightcrew that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas.

(b) Procedures for exiting icing conditions must be established.

Justification

Change wording in 25.1420 to be consistent with existing 25.1419

Comment # 2

Document, Section Title & Paragraph
NPRM, § 25.1420 Exit large droplet conditions.

Existing Text
Page 22 of 22:
§ 25.1420 Exit large droplet conditions.

(a) For airplanes with reversible roll or pitch controls: if certification for flight in icing conditions is desired, one of the following must be provided to alert the flightcrew that they must exit icing conditions

(1) Substantiated visual cues that enable the flightcrew to determine that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas; or

(2) A system that alerts the flightcrew that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas.

Proposed Text Language
§ 25.1420 Exit icing conditions outside Appendix C.

(a) If certification for flight in icing conditions is desired, one of the following must be provided to alert the flightcrew that they must exit icing conditions

(1) A system that alerts the flightcrew that the airplane is in icing conditions outside Appendix C, or

Substantiated visual cues that enable the flightcrew to determine that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas.
unless these icing conditions are included in the certification for flight in icing conditions.

Justification
It is known that icing conditions outside Appendix C occur. If an airplane is in icing conditions where it is not certified for, it has to exit icing conditions.

All airplanes will be affected by ice accretion due to supercooled large droplets, especially if the aircraft has <u>clean</u> protected areas. Runback ice due to SLD can be significant. Also remember the significant effect of so-called sandpaper ice. It has to be demonstrated that the effect of ice accretion due to supercooled large droplets on airplane performance and handling is acceptable if continued operation in those conditions is desired.
The difference in performance margin during all engine flight between jet and turboprop airplane is certainly not always in favor of jet aircraft but depends on the design.

Also the effect of SLD on propeller performance has to be considered. Runback ice on a propeller can reduce the thrust with about 30 %, although "normal" icing reduces the thrust with only a few percent.

Regarding airplanes with reversible roll or pitch controls: The protected areas (for instance de-icing boots) can be of constant chord percentage (more recent designs optimized by calculations?), or constant chord wise length (more older designs demonstrated extensively in flight tests?), or a combination of those two. If the protected parts are of constant chord percentage then ice accretion aft of the protected areas has to be expected to occur first at the thinnest profiles such as on the wingtip i.e. in front of the roll controls. In that case no warning due to increased drag will occur but suddenly roll problems might occur (still depending on control design). In the other cases ice accretion aft of the protected area will start more inboard resulting "only" in a gradual degradation of drag and lift, which might be recognized by the flightcrew before it becomes hazardous. It has to be noted that sufficient boot coverage will also reduce the lift and drag degradation significantly.

Comment # 3

Document, Section Title & Paragraph (ex: NPRM, 5. Technology, 2nd Paragraph)

NPRM, proposed 25.1420 rule

Existing Text (excerpt, page, etc.)

§ 25.1420 Exit large droplet conditions.

(a) For airplanes with reversible roll or pitch controls: if certification for flight in icing conditions is desired, one of the following must be provided to alert the flightcrew that they must exit icing conditions

(1) Substantiated visual cues that enable the flightcrew to determine that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas; or

(2) A system that alerts the flightcrew that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas.

(b) Procedures for exiting icing conditions must be established.

Proposed Text Language

§ 25.1420 Exit large droplet conditions.

If certification for flight in icing conditions is desired, compliance with either (a) or (c) below must be demonstrated.

(a) One of the following must be provided to alert the flightcrew that they must exit icing conditions

(1) Substantiated visual cues that enable the flightcrew to determine that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas; or

(2) A system that alerts the flightcrew that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas.

(b) If compliance with (a) is to be demonstrated, procedures for exiting icing conditions must be established.

(c) The aerodynamic effects of ice accumulation aft of the protected areas must be shown to be such that exiting icing conditions is not required.

Justification

The language of the existing proposal suggests that airplanes with irreversible flight controls are not at risk when ice accumulates aft of the protected areas. With respect to hinge moment effects, this is true. However, depending on the chordwise extent of the protected surfaces and the airfoil section characteristics, ice accumulations aft of such areas may have significant impact on lift coefficient. These effects will be present regardless of whether the flight controls are reversible or not.

In fact, the database reviewed by the IPHWG contains 48 events in which the IPS was operated prior to the event taking place. It is not possible to know how many of these events involved ice accumulation aft of the protected areas. However, 11 of these contained evidence of SLD, including 1 in which ice aft of the protected areas was specifically reported. On the other hand, of the 48, only 3 involve tailplane flow separation of some type, and 1 involves a clear case of large droplet icing leading to a hinge moment shift in lateral control (Roselawn, October 1994).

Thus, hinge moment effects represent only a portion, albeit a well documented portion, of the events which may be associated with ice accumulation aft of the protected areas.

The work done by Bragg, et.al., investigating the effects of step shapes on aerodynamic characteristics concluded that the chordwise location which yielded the largest degradation in hinge moment coefficient also resulted in the largest degradation in lift coefficient. This location corresponded to 10% chord on the NACA 23012 airfoil section. An airfoil such as this which was equipped with irreversible flight controls would not need to meet the requirements set forth by the proposed 25.1420, yet may still experience significant lift degradations due to ice accretions aft of the protected area.

Whether or not sufficient aerodynamic warning of a loss in lift coefficient would be perceptible to the flight crew is not clear, and is certainly not sufficiently clear to rely on for the purpose of new design. In a dynamic flight environment, a drag rise associated with a loss of lift may not be detected until past the point at which the available power will allow recovery. When combined with low altitude, this situation could be very serious.

This rule is being promulgated at a time when the perspective on inflight icing has changed considerably from what it was the last time icing certification rules were changed. Today, high density operations are conducted using structured traffic flows into several airports geographically positioned to experience considerable icing per annum. These include Chicago and Detroit. The strong pressure exerted on design by rising fuel costs creates incentive to minimize the energy available for ice protection. A great deal more is known about the character and probability of large droplet icing conditions than was known before. These factors together make a compelling case for a cautious approach to the interpretation of past data, such as accident/incident histories, for direct relevance to future designs. A new certification rule which encompasses a wise consideration of the future operating environment, and which anticipates those situations which cannot be clearly excluded based on engineering knowledge, would seem to be the most prudent course to follow.

Comment #4

Document, Section Title & Paragraph (ex: NPRM, 5. Technology, 2nd Paragraph)

NPRM, 5. Technology, starting with 5th paragraph (I think)

Existing Text (excerpt, page, etc.)

p. 12:

However, an ice detection system with the capability to alert the flightcrew when to exit icing conditions would have to be able to detect when:

a. the icing conditions encountered exceed the criteria to which the airplane was certified;

or

b. ice is accreting on surfaces of the airplane where it could prove hazardous and that were not addressed in the airplane's icing certification.

Some ice detection systems . . . . However, these detectors only measure ice accretions and are not able to perform either of the functions identified as a. and b., above.

Due to the limitations . . . .

It is feasible for the current ice detector technology to identify the existence of ice aft of the protected areas . . . .

Proposed Text Language

[same from "However, an ice detection . . . . " through "Some ice detection systems . . . 0.5 mm or less are detectable."] However, these detectors only measure ice accretions and are not able to perform the function identified as (a) above.

It is feasible for the current ice detector technology to identify . . . .

Due to the limitations . . . .

The IPHWG also acknowledged . . . .

Justification

I think there's a problem here with being contradictory. First we say that detectors are NOT able to detect ice as per (b), and then further down the page, we say it IS feasible for current detectors to detect ice aft of the protected areas – but we'd just said they can't do that. I propose eliminating (b) from the statement of what the detectors can't do.

The "Due to the limitations . . . " paragraph seems out of place when you read the paragraphs above and below; it also loses some teeth if the reference to (b) is eliminated, particularly since we say a detector would only have do either (a) OR (b). It seems to work to move that paragraph down below the "It is feasible . . . ." paragraph, which then leads into discussion of means other than detectors.

Comment #5

Document, Section Title & Paragraph (ex: NPRM, 5. Technology, 2nd Paragraph)

NRPM, § 25.1420

Existing Text (excerpt, page, etc.)
p. 22:

§ 25.1420 Exit large droplet conditions.

(a) For airplanes with reversible roll or pitch controls: if certification for flight in icing conditions is desired, one of the following must be provided to alert the flightcrew that they must exit icing conditions

(1) Substantiated visual cues that enable the flightcrew to determine that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas; or

(2) A system that alerts the flightcrew that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas.

(b) Procedures for exiting icing conditions must be established.

Proposed Text Language

§ 25.1420 Exit large droplet conditions.
If certification for flight in icing conditions is desired:

(a) One of the following must be provided to alert the flightcrew that they must exit icing conditions:

(1) Substantiated visual cues . . . .

(2) A system that alerts the flightcrew . . . .

(b) Procedures for exiting icing conditions must be established.

(c) Compliance with (a) and (b) is not required if it can be shown that it is not necessary for the airplane to exit large droplet conditions conducive to ice accumulation aft of the airframe's protected areas.

Justification

Given that there are a number of events which could well have been performance degradation situations (loss of lift and/or increase in drag) rather than hinge-moment anomalies, as well as a number of events in which the cause is unknown, this rule should not be focused on one specific (type of) event. Nor should it be limited to a current design feature; like the rest of the cert rule, it should not presume to know what designs might appear in the future and how they will behave in SLD.

At the same time, it would not be prudent to penalize all new airplanes. The "out" provided by paragraph (c) can be accomplished prior to completion of Task 2 by applying reasonable assumptions and engineering judgment to existing methods (with agreement of the certifying agencies, of course) – as an example, see the corresponding AC Comment 21b.

Comment #6

Document, Section Title & Paragraph (ex: NPRM, 5. Technology, 2nd Paragraph)

AC, 9. Compliance with § 25.1420

Existing Text (excerpt, page, etc.)
p. 12:

a. Requirement of the Rule. Section 25.1420 is applicable to aircraft equipped with reversible flight controls in either the pitch or roll axis. The paragraph requires . . . .

Proposed Text Language

a. Requirement of the Rule. Section 25.1420 is applicable to all aircraft unless the applicant can show that it is not necessary for the aircraft to exit large droplet conditions conducive to ice accumulation aft of the airframe's protected areas. It requires . . . .

* * *

c. [New Paragraph] Showing That It Is Not Necessary to Exit.

(1) In the absence of another accepted definition, the following may be used as a representative environment for testing and analyses: 20 minute icing encounter, maximum droplet diameters of 400 microns, median volumetric diameter of 170 microns, liquid water content approximately 0.6 grams per cubic meter, and temperature near freezing.

(2) Ice shapes may be derived for representative airfoil sections by icing wind tunnel or icing tanker tests. Interpolation and extrapolation may be used to complete the ice shape estimate for the surface. Once representative ice shapes have been determined, fabricated ice shapes may be used for dry air wind tunnel or flight testing.

(3) With the ice shapes determined above affixed to the airplane, all handling qualities and performance requirements for flight-in-icing certification, in accordance with the airplane's certification basis, must be met.

Justification

Obviously a lot more could, and should, go into this but it's just an example of what might be written to allow an "out." It can all be updated as we get smarter with Task 2 and as tools for generating SLD ice shapes mature.

(1) This definition comes from the FAA's generic Issue Paper on Roll Control in SLD.
(2) Icing tunnels and tankers are allowed for numerous applications throughout this AC; it is absurd to say that they cannot be used to generate representative ice shapes.
(3) This might be rulemaking but you get the idea.

Comment # 7
Document, Section Title & Paragraph (ex: NPRM, 5. Technology, 2nd Paragraph)

Proposed Advisory Circ., Section 3. Related Documents, Applicable regulations.

Existing Text (excerpt, page, etc.):

Reference to § 25.1321 & § 25.1333, page 2

Proposed Text Language:

Delete

Justification

§25.1321 address flight, navigation and powerplant instruments. Flight and navigation instruments are defined in §25.1303. Powerplant instruments are defined in §25.1305.

§25.1333 is stated to be applicable to systems that operate the instruments required by §25.1303(b).

These paragraphs are directed towards primary flight instruments. Don't believe there was any intent to raise the status of an ice detector indication to the same level as primary flight, navigation or powerplant instruments.

Comment # 8
Document, Section Title & Paragraph (ex: NPRM, 5. Technology, 2nd Paragraph)

Proposed Advisory Circ., Section 3. Related Documents, Advisory Circulars, Section 5, Page 7

Existing Text (excerpt, page, etc.):

(a) Field of View. The visual cue should be developed with the following considerations:
(i) Visual cues should be within the flightcrew's vision scan area while seated and performing their normal duties.
(ii) The visual cue should be visible during all modes of operation (day, night).
(b) Verification. During the certification process, the applicant should verify the ability of the crew to observe the visual cue and reference surface. The visual cue should not be dependent upon the location of the flightcrew's seats. The visual cue should be evaluated from the most adverse flightcrew seat locations in combination with the range of flightcrew heights. The visual cues should be visible from both the left and right seats. Consideration should be given to the difficulty of observing clear ice. If a reference surface is used, the applicant should validate that it correlates with ice accumulation on the airframe's protected areas. Such visual cues should be validated by testing in measured natural icing.

Proposed Text Language:

(a) Field of View. The visual **cues** should be developed with the following considerations:
(i) Visual cues should be within the flightcrew's vision scan area while seated and performing their normal duties.
(ii) The visual **cues** should be visible during all modes of operation (day, night).
(b) Verification. During the certification process, the applicant should verify the ability of the crew to observe the visual **cues** ~~and~~ **or** reference **surfaces**. The visual **cues** should not be dependent upon the location of the flightcrew's seats. The visual **cues** should be evaluated from the most adverse flightcrew seat locations in combination with the range of flightcrew heights**, within the approved range of eye reference point locations, if available. A visual cue is required for both the left and right seats. If a single visual cue is used, it should be** ~~The visual cues should be~~ visible from ~~both the left and right~~ **either seat.** ~~seats.~~ Consideration should be given to the difficulty of observing clear ice. If a reference surface is used, the applicant should validate that it correlates with ice accumulation on the airframe's protected areas. Such visual cues should be validated by testing in measured natural icing.

Justification

Multiple visual cues or reference surfaces may be required for a specific aircraft. For example, a visual cue may be readily visible from the left seat, but not the right seat. However, a symmetric location on the right side of the aircraft could be defined as a second visual cue. This would meet the intent of having a cue available from either position. As written, seems to indicate that if a visual cue is not visible from either crew position, it is unacceptable. Do not believe this is the intent.

Also under (b) phrase "visual cues and references surfaces" implies both are required. Again, do not believe this is the intent.

Phrase "within the approved range of eye reference point locations, if available." was inserted in section addressing 25.1420. Appears to be equally appropriate here.

Comment # 9
Document, Section Title & Paragraph (ex: NPRM, 5. Technology, 2nd Paragraph)

Proposed Advisory Circ., Section 3. Related Documents, Advisory Circulars, Section 5, Page 8

Existing Text (excerpt, page, etc.):

(2) Section 25.1419 also requires a combination of tests and analysis to demonstrate the performance of the ice detector and the system as installed on the airplane. This could include icing tunnel and icing tanker tests to evaluate the ice detector performance. Also required are analysis and flight tests in measured natural atmospheric conditions to demonstrate satisfactory performance of the system as installed on the airplane. It should be demonstrated that the airplane can be safely operated with the ice accretions formed at the time the ice protection system becomes effective, following activation of the ice detector.

Proposed Text Language:

(2) Section 25.1419 also requires a combination of tests and analysis to demonstrate the performance of the ice detector and the system as installed on the airplane. This could include icing tunnel and icing tanker tests to evaluate the ice detector performance. Also required are analysis and flight tests in measured natural atmospheric conditions to demonstrate satisfactory performance of the system as installed on the airplane. **Droplet impingement analysis may be used in determining that the ice detector functions properly over the droplet range of Appendix C *when validated through natural or artificial icing tests (tanker, icing tunnel).*** It should be demonstrated that the airplane can be safely operated with the ice accretions formed at the time the ice protection system becomes effective, following activation of the ice detector.

Justification

It may be impractical to test the ice detector system performance over a wide range of droplet sizes with icing tankers. Icing tunnel tests may not be practical depending on the aircraft geometry surrounding the detector installation. Analysis is the most practical means of determining droplet trajectories over a wide range of drop sizes.

Comment # 10
Document, Section Title & Paragraph (ex: NPRM, 5. Technology, 2nd Paragraph)

Proposed Advisory Circ., Section 9. Compliance with §25.1420 b(3)(a)

Existing Text (excerpt, page, etc.):

(a) Field of View. The visual cue should be developed with the following considerations:
(i) Visual cues should be within the flightcrew's vision scan area while seated and performing their normal duties.
(ii) The visual cue should be visible during all modes of operation (day, night).
(b) Verification. During the certification process, the applicant should verify the ability of the crew to observe the visual cue and reference surface. The visual cue should not be dependent upon the location of the flightcrew's seats. The visual cue should be evaluated from the most adverse flightcrew seat locations in combination with the range of flightcrew heights, within the approved range of eye reference point locations, if available. The visual cues should be visible from both the left and right seats. Consideration should be given to the difficulty of observing clear ice. If a reference surface is used, the applicant should validate that it correlates with ice accumulation on the airframe's protected areas. Such visual cues should be validated by testing in measured natural icing. ……

Proposed Text Language:

(a) Field of View. The visual **cues** should be developed with the following considerations:
(i) Visual cues should be within the flightcrew's vision scan area while seated and performing their normal duties.
(ii) The visual **cues** should be visible during all modes of operation (day, night).
(b) Verification. During the certification process, the applicant should verify the ability of the crew to observe the visual **cues** ~~and~~ **or** reference **surfaces**. The visual **cues** should not be dependent upon the location of the flightcrew's seats. The visual **cues** should be evaluated from the most adverse flightcrew seat locations in combination with the range of flightcrew heights, within the approved range of eye reference point locations, if available. **A visual cue is required for both the left and right seats. If a single visual cue is used, it should be** ~~The visual cues should be~~ visible from ~~both the left and right~~ **either seat** ~~seats~~. Consideration should be given to the difficulty of observing clear ice. If a reference surface is used, the applicant should validate that it correlates with ice accumulation on the airframe's protected areas. Such visual cues should be validated by testing in measured natural icing.

Justification (same as comment 8)

Multiple visual cues or reference surfaces may be required for a specific aircraft. For example, a visual cue may be readily visible from the left seat, but not the right seat. However, a symmetric location on the right side of the aircraft could be defined as a second visual cue. This would meet the intent of having a cue available from either position. As written, seems to indicate that if a visual cue is not visible from either crew position, it is unacceptable. Do not believe this is the intent.

Also under (b) phrase "visual cues and references surfaces" implies both are required. Again, do not believe this is the intent.

Phrase "within the approved range of eye reference point locations, if available." was inserted in section addressing 25.1420. Appears to be equally appropriate here.

Comment # 11
Document, Section Title & Paragraph (ex: NPRM, 5. Technology, 2nd Paragraph)

Preamble, Summary

Existing Text (excerpt, page, etc.):

SUMMARY: This proposal would amend the regulations applicable to transport category airplanes certificated for flight in icing. The proposal would require either the installation of a primary ice detection system; or the definition of visual cues for recognition of ice accretion on a specified surface, combined with an advisory ice detector that provides an alert. For airplanes with reversible flight controls in the pitch or roll axis, the proposal would also require a means to indicate to the flightcrew that the airplane is in conditions conducive to ice accumulation aft of the airframe's protected areas. This proposed regulation is the result of information gathered from a review of icing accidents and incidents, and it is intended to improve the level of safety when airplanes are operated in icing conditions.

Proposed Text Language:

SUMMARY: This proposal would amend the regulations applicable to transport category airplanes certificated for flight in icing. The proposal would require either the installation of a primary ice detection system; ~~or~~ the definition of visual cues for recognition of ice accretion on a specified surface, combined with an advisory ice detector that provides an alert**; or the identification of conditions conducive to airframe icing through the use of temperature and visible moisture cues.** For airplanes with reversible flight controls in the pitch or roll axis, the proposal would also require a ~~means~~ **method** to indicate to the flightcrew that the airplane is in conditions conducive to ice accumulation aft of the airframe's protected areas. This proposed regulation is the result of information gathered from a review of icing accidents and incidents, and it is intended to improve the level of safety when airplanes are operated in icing conditions.

Justification

The third method of operating the ice protection systems needs to be addressed in the summary.

With the recent FAA legal interpretation that "a means" is a device. The use of means is inappropriate given that other compliance methods rather than devices are acceptable.

Comment # 12
Document, Section Title & Paragraph (ex: NPRM, 5. Technology, 2nd Paragraph)

Preamble, Operating Regulations (Page 4)

Existing Text (excerpt, page, etc.):

Operating Regulations. There also are relevant regulations that apply to airplane operations, which are found in 14 CFR part 121 ("Operating Requirements: Domestic, Flag, and Supplemental Operations"). Specifically, § 121.629(a) ("Operation in icing conditions") states:
"No person may dispatch or release an aircraft, continue to operate an aircraft en route, or land an aircraft when in the opinion of the pilot in command or aircraft dispatcher (domestic and flag operations only), icing conditions are expected or met that might adversely affect the safety of the flight."

Also, § 121.341 ("Equipment for operations in icing conditions") requires the installation of certain types of ice protection equipment and wing illumination equipment.

Neither the operating regulations nor the certification regulations require a means for the pilot-in-command specifically to identify that hazardous icing conditions have been encountered.

Proposed Text Language:

Operating Regulations. There also are relevant regulations that apply to airplane operations, which are found in **14 CFR part 91 ("General Operating and Flight Rules"),** 14 CFR part 121 ("Operating Requirements: Domestic, Flag, and Supplemental Operations") **and 14 CFR part 135 ("Operating Requirements: Commuter and On Demand Operations and Rules Governing Persons On Board Such Aircraft").**

Specifically, § 91.527 ("Operation in icing conditions") and § 135.227 ("Icing conditions: Operating limitations") address limitations in icing conditions for aircraft operated under this flight rules.

Specific comments regarding exiting hazardous icing conditions are found in Part § 121.629(a) ("Operation in icing conditions") ***which*** states:
"No person may dispatch or release an aircraft, continue to operate an aircraft en route, or land an aircraft when in the opinion of the pilot in command or aircraft dispatcher (domestic and flag operations only), icing conditions are expected or met that might adversely affect the safety of the flight."

Also, § 121.341 ("Equipment for operations in icing conditions") requires the installation of certain types of ice protection equipment and wing illumination equipment.

Neither the operating regulations nor the certification regulations require a means for the pilot-in-command specifically to identify that hazardous icing conditions have been encountered.

Justification

Don't believe we can discuss a part 25 certification rule and only address part 121. There are plenty of small part 25 aircraft operating under parts 91 & 135. It may be sufficient to just mention the other parts and not get into the dilemma that part 91 & 135 don't address the concept of prohibiting operation in icing conditions that might adversely affect the safety of flight. The last sentence "Neither the operating regulations ..." still follows when the other parts are included.

[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 25

[Docket No. FAA-2001-________; Notice No.____________]

RIN 2120-____________

Operations in Icing Conditions

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: This proposal would amend the regulations applicable to transport category airplanes certificated for flight in icing. The proposal would require either the installation of a primary ice detection system; or the definition of visual cues for recognition of ice accretion on a specified surface, combined with an advisory ice detector that provides an alert. For airplanes with reversible flight controls in the pitch or roll axis, the proposal would also require a means to indicate to the flightcrew that the airplane is in conditions conducive to ice accumulation aft of the airframe's protected areas. This proposed regulation is the result of information gathered from a review of icing accidents and incidents, and it is intended to improve the level of safety when airplanes are operated in icing conditions.

DATES: Send your comments on or before [Insert date 90 days after date of publication in the Federal Register.].

ADDRESSES: Address your comments to the Docket Management System, U.S. Department of Transportation, Room Plaza 401, 400 Seventh Street, SW., Washington, DC 20590-0001. You must identify the docket number FAA-2001-__________ at the beginning of your comments, and you should submit two copies of your comments. If you wish to receive confirmation that FAA received your comments, include a self-addressed, stamped postcard.

You may also submit comments through the Internet to http://dms.dot.gov. You may review the public docket containing comments to these proposed regulations in person in the Dockets Office between 9:00 a.m. and 5:00 p.m., Monday through Friday, except Federal holidays. The Dockets Office is on the plaza level of the NASSIF Building at the Department of Transportation at the above address. Also, you may review public dockets on the Internet at http://dms.dot.gov.

FOR FURTHER INFORMATION CONTACT: Kathi Ishimaru, FAA, Propulsion/Mechanical Systems Branch, ANM-112, Transport Airplane Directorate, Aircraft Certification Service, 1601 Lind Avenue SW., Renton, WA 98055-4056; telephone (425) 227-2674; facsimile (425) 227-1320, e-mail kathi.ishimaru@faa.gov.

SUPPLEMENTARY INFORMATION:

Comments Invited

Interested persons are invited to participate in the making of the proposed action by submitting such written data, views, or arguments as they may desire. Comments relating to the environmental, energy, federalism, or economic impact that might result from adopting the proposals in this document also are invited. Substantive comments should be accompanied by cost estimates. Comments must identify the regulatory docket or notice number and be submitted in duplicate to the DOT Rules Docket address specified above.

All comments received, as well as a report summarizing each substantive public contact with FAA personnel concerning this proposed rulemaking, will be filed in the docket. The docket is available for public inspection before and after the comment closing date.

All comments received on or before the closing date will be considered by the Administrator before taking action on this proposed rulemaking. Comments filed late will be considered as far as possible without incurring expense or delay. The proposals in this document may be changed in light of the comments received.

Commenters wishing the FAA to acknowledge receipt of their comments submitted in response to this document must include a pre-addressed, stamped postcard with those comments on which the following statement is made: "Comments to Docket No. FAA-2001-___________." The postcard will be date stamped and mailed to the commenter.

Availability of NPRM Documents

You can get an electronic copy using the Internet by taking the following steps:

(1) Go to the search function of the Department of Transportation's electronic Docket Management System (DMS) web page (http://dms.dot.gov/search).

(2) On the search page type in the last four digits of the Docket number shown at the beginning of this notice. Click on "search."

(3) On the next page, which contains the Docket summary information for the Docket you selected, click on the document number of the item you wish to view.

You can also get an electronic copy using the Internet through FAA's web page at http://www.faa.gov/avr/arm/nprm/nprm.htm or the Federal Register's web page at http://www.access.gpo.gov/su_docs/aces/aces140.html.

You can also get a copy by submitting a request to the Federal Aviation Administration, Office of Rulemaking, ARM-1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267-9680. Make sure to identify the docket number, notice number, or amendment number of this rulemaking.

BACKGROUND

On October 31, 1994, an accident involving an Aerospatiale Model ATR72 series airplane occurred in which icing conditions, believed to include freezing drizzle droplets, were reported in the area. The FAA, Aerospatiale, the French Direction Générale de l'Aviation Civile, Bureau Enquète Accident, National Aeronautics and Space Administration (NASA), National Transportation Safety Board (NTSB), and others have conducted an extensive investigation of this accident. This investigation has led to the conclusion that freezing drizzle conditions created a ridge of ice aft of the deicing boots and forward of the ailerons, which resulted in uncommanded roll of the airplane.

Existing Regulations

Certification Regulations. The current regulations that are applicable to transport category airplanes for flight in icing conditions are contained in Title 14, Code of Federal Regulations (14 CFR) part 25 (§ 25.1419, "Ice protection"). This regulation requires that an airplane must be able to safely operate in the continuous maximum and intermittent maximum icing conditions of 14 CFR part 25, appendix C. Appendix C characterizes continuous maximum and intermittent maximum icing conditions within stratiform and cumuliform clouds. Freezing precipitation (freezing drizzle and freezing rain) is not included. Appendix C defines icing cloud characteristics (for both small and transport airplanes) in terms of mean effective drop diameters, liquid water content, temperature, horizontal extent, and altitude. Icing conditions containing freezing drizzle and freezing rain sometimes result in mean effective diameters that are larger than the mean effective drop diameters defined in appendix C. Consequently, these icing conditions containing freezing drizzle and freezing rain are not considered during the certification of the airplane's ice protection system, and exposure to these conditions could result in hazardous ice accumulations.

Operating Regulations. There also are relevant regulations that apply to airplane operations, which are found in 14 CFR part 121 ("Operating Requirements: Domestic, Flag, and Supplemental Operations"). Specifically, § 121.629(a) ("Operation in icing conditions") states:

> "No person may dispatch or release an aircraft, continue to operate an aircraft en route, or land an aircraft when in the opinion of the pilot in command or aircraft dispatcher (domestic and flag operations only), icing conditions are expected or met that might adversely affect the safety of the flight."

Also, § 121.341 ("Equipment for operations in icing conditions") requires the installation of certain types of ice protection equipment and wing illumination equipment.

Neither the operating regulations nor the certification regulations require a means for the pilot-in-command specifically to identify that hazardous icing conditions have been encountered.

NTSB Safety Recommendations

The NTSB issued various safety recommendations to the FAA following the Model ATR72 accident. One of the recommendations, A-96-56, states in part that:

> ". . . If safe operations in certain icing conditions cannot be demonstrated by the manufacturer, operational limitations should be imposed to prohibit flight in such conditions and flightcrews should be provided with the means to positively determine when they are in icing conditions that exceed the limits for aircraft certification."

In response to the latter portion of this safety recommendation, the FAA tasked the Aviation Rulemaking Advisory Committee (ARAC), by notice published in the Federal Register on December 8, 1997 (62 FR 64621), to do the following:

> ". . . consider the need for a regulation that requires installation of ice detectors, aerodynamic performance monitors, or another acceptable means to warn flightcrews of ice accumulation on critical surfaces requiring crew action (regardless of whether the icing conditions are inside or outside of appendix C of 14 CFR part 25)."

The Aviation Rulemaking Advisory Committee (ARAC)

The ARAC was formally established by the FAA on January 22, 1991 (56 FR 2190), to provide advice and recommendations concerning the full range of the FAA's safety-related rulemaking activity. The FAA sought this advice to develop better rules in less overall time, using fewer FAA resources than are currently needed. The committee provides the opportunity for the FAA to obtain firsthand information and insight from interested parties regarding proposed new rules or revisions of existing rules.

There are 64 member organizations on the committee, representing a wide range of interests within the aviation community. Meetings of the committee are open to the public, except as authorized by section 10(d) of the Federal Advisory Committee Act.

The ARAC establishes working groups to develop proposals to recommend to the FAA for resolving specific issues. Tasks assigned to working groups are published in the Federal Register. Although working group meetings are not generally open to the public, all interested parties are invited to participate as working group members. Working groups report directly to the ARAC, and the ARAC must accept a working group proposal before that proposal can be presented to the FAA as an advisory committee recommendation.

The activities of the ARAC will not, however, circumvent the public rulemaking procedures. After an ARAC recommendation is received and found acceptable by the FAA, the agency proceeds with the normal public rulemaking procedures. Any ARAC participation in a rulemaking package will be fully disclosed in the public docket.

In response to the FAA's tasking of December 8, 1997 (see above), ARAC's Ice Protection Harmonization Working Group (IPHWG) developed recommendations for

FAA rulemaking to address flight in icing conditions. The ARAC accepted those recommendations and presented them to the FAA. The FAA has reviewed and accepted those recommendations, and has based the rulemaking proposal contained in this NPRM on them.

DEVELOPMENT OF THE PROPOSAL

Review Process

To address the FAA's tasking, the IPHWG followed a process consisting of the following five elements:

1. Review of the airplane icing related accident/incident history,
2. Identification of safety concerns,
3. Identification of the airplanes subject to the safety concerns (i.e., applicability),
4. Identification of various means to address the safety concerns, and
5. Review of the technology available to allow compliance with any proposed methods of addressing the safety concerns.

These five elements are discussed in more detail below.

1. Accident/Incident History Review

The IPHWG reviewed the airplane icing related accident/incident history and developed a database of approximately 1,300 worldwide icing-related accident and incident reports. The IPHWG then refined the database by:

- Removing duplicate entries and reports with insufficient data.
- Removing elements that were not relevant to inflight airframe icing problems, such as reports related to ground deicing and carburetor icing.

- Excluding single-engine piston airplanes, because most of these airplanes are not certificated for flight in icing. (Although a few of these airplanes may be certificated and equipped for flight in icing, the IPHWG considered that their exclusion would not affect the outcome of the review.)
- Removing reports involving multi-engine piston airplanes that were not certificated for flight in icing.
- Removing reports of events in which externally aggravating circumstances existed, such as operation of the airplane outside of its weight and balance limitations, descent below published minimums, or other reasons not related to airplane icing.

The IPHWG reviewed the remaining events and identified 61 events that were relevant to the task of determining the need for an ice detector. The IPHWG applied the following criteria to make this determination:

- Was there ice accretion that was not known to the flightcrew?

and

- Would knowledge of this ice accretion have made a difference to the outcome of the accident or incident?

Based on these 61 events, the IPHWG concluded that there is substantive documented accident and incident history in which the existing level of flightcrew cognizance of ice buildup on airframe surfaces is not adequate.

2. Safety Concerns

Activation of Airframe Ice Protection Systems (IPS). The airplane icing-related accident/incident history review revealed accidents and incidents where the flightcrew either:

- was completely unaware of ice accumulation on the airframe, or
- was aware of ice accumulation, but judged that it was not significant enough to warrant operation of the IPS.

From this, the IPHWG concluded that flightcrews must be provided with a clear means to know when to activate the IPS.

Exit Icing Conditions. The database contains reports of accidents and incidents where the IPS was operated according to accepted procedures, yet the ice accretions still created degradations that led to an event. Therefore, the IPHWG concluded that the flightcrew must be provided with a means to know if the airplane is in conditions conducive to ice accumulation that warrant the flightcrew taking actions to exit those icing conditions.

3. Applicability

Activation of Airframe Ice Protection Systems (IPS). The IPHWG examined the accident and incident history and found that discriminating design factors exist, such as wing chord length or airplane weight, that significantly reduce the risk of icing accidents and incidents. These discriminators were applied to the IPHWG recommended Operation Rule proposals, which are retrospective and apply to airplane types currently in service. However, the IPHWG recommended that a certification rule dealing with ice detectors should not be limited to a specific group of airplanes because of past performance. Future airplane designs may change and a similar safety record may not be achieved. Therefore, reliance on past performance for future airplane designs would not be prudent.

Exit Icing Conditions.

There have been a number of accidents and incidents caused by the uncommanded deflections of reversible flight controls in both pitch and roll axes in icing conditions. These uncommanded deflections were the result of ice accreting ahead of the control surfaces, either aft of the protected area or on the protected area when the IPS was not activated. This resulted in airflow separation over a control surface. Such an airflow separation changes the pressure distribution on the control surface. The resulting control force change may be quite large, with significant difficulty for the flightcrew to manage. In some cases, the flightcrew may not be able to regain control of the airplane.

There is no history in the database of accidents or incidents due to uncommanded rudder deflections. Due to engine inoperative and crosswind landing requirements, the rudder is designed for operation at high deflection angles without force reversal. Normal airplane operation does not expose the vertical stabilizer to high sideslip angles (angle-of-attack), thereby leaving a large stall margin.

For irreversible flight controls, the control surface actuators are sized to maintain the control surface in its commanded position throughout the airplane's flight envelope, including high-speed dive. This results in the design loads for the actuators being larger than the loads induced by airflow separation caused by ice accretions aft of the airplane's protected areas. Therefore, airplanes with irreversible flight controls have not experienced uncommanded control surface deflection caused by ice accretions.

This caused the IPHWG to maintain unpowered flight controls as a discriminator in the proposed cert rule 25-1420 pertaining to exit of icing conditions.

4. Possible Means of Addressing the Safety Concerns

Activation of Airframe Ice Protection Systems (IPS). For some types of aircraft previously certified, the safety concern of when to activate the IPS has already been partially addressed by Airworthiness Directives (AD's). The FAA has issued AD's to require activation of pneumatic deicing boots at the first signs of ice accumulation on the airplane. These AD's relieve the pilot of determining if the amount of ice accumulated on the wing warrants activation of the IPS. However, activation of the deicing boots is still subject to the flightcrew's observation of ice accumulations, and such observations can be difficult during times of high workload, operations at night, or when clear ice has accumulated. Also, the difficulties of observing ice accumulations is applicable to any IPS that relies on the flightcrew's observations for activating the system, not just pneumatic deicing boots.

The IPHWG concluded that an improved means to address these situations for future aircraft would be to require installation of a device that would alert the flightcrew when it was appropriate to activate the IPS. A primary ice detection system would be one acceptable means to alert the flightcrew. It could either automatically activate the IPS, or provide an indication to the flightcrew when the system must be activated. An advisory ice detection system, in conjunction with substantiated visual cues, will provide a much higher level of safety than visual cues alone. These means would mitigate the effects of human sensory limitations and of inadequate attention.

An alternative to requiring the installation of an ice detector would be to require that the IPS be operated whenever the airplane is operating in conditions conducive to airframe icing. The IPS would be operated in these conditions during all phases of flight, unless it can be shown that the IPS need not be activated during certain phases of flight. In this case, the flightcrew would initiate the ice protection system in response to a specific air temperature threshold and the presence of visible moisture. Because temperature and visible moisture information is readily available and unambiguous, deciding when to initiate the system would require little increased effort by the flightcrew.

The IPS continuous operation approach has disadvantages with respect to increased maintenance due to increased time in operation. However, it presents great advantages with respect to flightcrew workload and procedural reliability. It is consistent with systems used as anti-ice systems and is the procedure in use for many thermally anti-iced small jets. The IPHWG noted that small jets that used these procedures were absent from the event data base. The IPHWG considered that this procedure could be used as an alternative to an ice detection system.

The flightcrew must be provided with a clear means to know when to activate the IPS both for the initial activation and on a continuing basis. The FAA is concerned with the flightcrew workload created if an IPS must be manually cycled. An IPS that is automatically cycled or operates on a continuous basis (for example, an anti-icing system) does not create this additional workload and, therefore, is not a concern. The workload can be alleviated by equipping airplanes with a system that automatically cycles the ice protection system or with an ice detection system that alerts the flightcrew each time the IPS must be cycled.

Exiting Icing Conditions. The safety concern of when to exit icing conditions was partially addressed for existing airplanes in 1996 by a series of AD's that the FAA issued and further addressed by the IPHWG Operating Rule proposals. [AD 96-09-22, amendment 39-9698, (61 FR 20674, May 7, 1996), is typical of these AD's.] The AD's require certain airplanes to exit icing when the conditions exceed the design conditions of the ice protection equipment. Generally, the visual cues for determining that the flightcrew must act to exit icing conditions are subjective and can result in varying interpretations. Terms such as, "unusually extensive ice," ice that is "not normally observed," and ice that is "farther aft than normally observed" are used in the AD's. These are all variable terms that are largely dependent on flightcrew experience. The IPHWG concluded that more definitive means of determining when the flightcrew should exit icing conditions are needed.

As previously discussed, NTSB recommendation A-96-56 states that if safe operations in certain icing conditions cannot be demonstrated by the manufacturer, operational limitations should be imposed to prohibit flight in such conditions. The current state of the art in "icing conditions that are conducive to ice accumulation aft of the airframe's protected areas" do not allow accurate investigation into the aircraft flying qualities with such accretions. The ability to determine flight characteristics with such conditions is dependent on the development of engineering definitions for these conditions and further developments in the engineering tools used to examine the ice accretions developed under these conditions.

It is recognized that the proposed rule does not permit an option that would allow continued flight in such conditions. This is due to the inability to demonstrate handling qualities given the existing state of knowledge on such conditions. The IPHWG is tasked with future work to define such conditions and has recommended future developments of the engineering tools in this respect. However, this work is ongoing and will not be available in the time frame of the proposed certification rule. The rule as proposed addresses the NTSB recommended safety concern by requiring the identification of such conditions with subsequent exit.

After the completion of the IPHWG tasking to define a supercooled large droplet environment and further maturity of the engineering tools, future rulemaking may be required to provide an option other than exiting the conditions. Much of the framework for criteria to be used in evaluating the effects of such accretions is already in the ARAC approval process. The Flight Test Harmonization Working Group (FTHWG) has recommended proposed rulemaking on defining acceptable flight characteristics in icing conditions. These proposals were drafted to accommodate possible modifications of Appendix C of 14 CFR Part 25 to account for large drop conditions. It is expected that these proposed rules will be used in defining acceptable criteria for handling quality evaluations to ensure that aircraft can either safely transition the conditions or safely exit them once the ability to define and simulate such conditions are available.

5. Technology

To ensure that viable means exist for compliance with any proposed methods of addressing the safety concerns, the IPHWG reviewed the current state of technology with regard to ice detectors and aerodynamic performance monitors.

Ice detector technology is sufficiently mature that there currently are available several methods that can reliably alert the flightcrew as to when the ice protection system should be activated. This type of technology already has been certificated on various airplanes as either an advisory or a primary means of determining when the ice protection systems should be activated.

One ice detection system to indicate when a de-icing ice protection system should be initially activated and subsequently cycled is commercially available. Sensors for such ice detection systems, installed on the protected surfaces, sense the accumulation of ice that is sufficient to warrant cycling of a deicing system. Other ice detection systems capable of sensing the rate of ice accumulation may be used to indicate when a deicing IPS should be cycled based on ice accumulation from the preceding cycling of the system. The IPHWG, therefore, considers that these existing technologies could be further developed to effectively indicate when the initial and subsequent cycling of a deicing IPS should occur.

However, an ice detection system with the capability to alert the flightcrew when to exit icing conditions would have to be able to detect when:

a. the icing conditions encountered exceed the criteria to which the airplane was certificated; or

b. ice is accreting on surfaces of the airplane where it could prove hazardous and that were not addressed in the airplane's icing certification.

Some ice detection systems currently installed on airplanes have the capability to detect and alert the flightcrew that ice is accreting on sensor elements of the detector. Depending upon the intended application of these detectors, ice accretions of approximately 0.5 mm or less are detectable. However, these detectors only measure ice accretions and are not able perform either of the functions identified as a. and b., above.

Due to the limitations of ice detector systems and the immature development of aerodynamic performance monitors, the IPHWG considered additional means for the flightcrew to know when they should exit icing conditions.

It is feasible for the current ice detector technology to identify the existence of ice aft of the protected areas. Based on the accident and incident history and the current state of ice detector technology, the IPHWG recommended that the regulations be revised to address the known safety concern of ice accumulations aft of the airframe's ice protection systems on airplanes with reversible flight controls in the pitch or roll axis. The FAA accepted that recommendation, and the subject of this NPRM is limited to addressing that known safety concern. The FAA will consider further rulemaking if improvements occur in the technology of the ice detectors or aerodynamic performance monitors.

The IPHWG also acknowledged that, instead of an ice detector, it might be possible to use the flightcrew's observation of ice accretion on reference surfaces, provided that the visual cues are substantiated for the specific airplane. This may appear to be inconsistent with the earlier determination that visual cues should not be relied upon for determining when the ice protection system should be activated. However, the visual cues would only be acceptable if the surface was close to the flightcrew and easily observable, such as icing on the side window of the flight deck.

The relevant icing accidents and incidents occurred on airplanes equipped with pneumatic deicing boots. However, the accumulation of ice aft of the protected areas due to large droplet icing conditions can occur on any airplane, regardless of the type of ice protection system installed on it. Therefore, the IPHWG recommended that any revision to the current regulations should be applicable regardless of the type of ice protection system installed.

DEFINITION OF TERMS

For the purposes of this proposed rule, the following definitions are applicable. These definitions of terms are intended for use only with this rule:

a. **Advisory ice detection system:** An advisory system annunciates the presence of ice accretion or icing conditions. The flightcrew is responsible for monitoring the icing conditions or ice accretion as defined in the Airplane Flight Manual (AFM), typically using total air temperature and visible moisture criteria, visible ice accretion, or specific airframe ice accretion thickness, and activation by the flightcrew of the anti-icing or de-icing system(s) remains a requirement. The advisory system provides information to advise the flightcrew of the presence of ice accretion or icing conditions, but it can only be used in conjunction with other means to determine the need for, or timing of, activating the anti-icing or de-icing system.

b. **Airframe icing:** Ice accretions on portions of the airplane, with the exception of the propulsion system, on which supercooled liquid droplets may impinge.

c. **Anti-Icing:** The prevention of ice formation or accumulation on a protected surface, either:

- by evaporating the impinging water; or
- by allowing it to run back and off the surface or freeze on non-critical areas.

d. **Automatic cycling mode:** A mode of operation of the airframe de-icing system that provides repetitive cycles of the system without the need for the pilot to select each cycle. This is generally done with a timer, and there may be more than one timing mode.

e. **Deicing:** Removal or the process of removal of an ice accretion after it has formed on a surface.

f. **Irreversible flight controls:** All of the force required to move the pitch, roll, or yaw control surfaces is provided by hydraulic or electric actuators, the motion of which is controlled by signals from the flight deck controls. Loads generated at the control surfaces themselves are reacted against the actuator and its mounting, and cannot be transmitted directly back to the flight deck controls.

g. **Large droplet conditions conducive to ice accumulation aft of the airframe's protected area:** Conditions containing a population of supercooled droplets sufficiently larger than those provided for in Appendix C (of 14 CFR part 25) to cause ice accretions aft of the protected areas. The accumulation mechanism aft of the protected surface may be by direct impingement and accretion, or delayed freezing of large droplets that impinge further forward. These conditions may be aircraft-dependent as a consequence of the geometry of the airfoil and the limits of protected areas.

h. **Monitored Surface:** The surface of concern regarding ice hazard (for example, the leading edge of the wing).

i. **Primary ice detection system:** The means used to determine when the IPS must be activated. The system annunciates the presence of ice accretion or icing conditions, and may also provide information to other aircraft systems. A primary automatic system automatically activates the anti-icing or de-icing systems. With a primary manual system, the flightcrew activates the IPS upon indication from the system.

j. **Reference Surface:** The surface where an ice detection sensor is located or where a visual cue is located remotely from the surface of concern regarding ice hazard (for example, a propeller spinner).

k. **Reversible flight controls:** The flight deck controls are connected to the pitch, roll, or yaw control surfaces by direct mechanical linkages, cables, or push-pull rods, such that pilot effort produces motion or force about the hinge line. Conversely, force or motion originating at the control surface (through aerodynamic loads, static imbalance, or trim tab inputs, for example) is transmitted back to flight deck controls.

- Aerodynamically boosted flight controls: Reversible flight control systems that employ a movable tab on the trailing edge of the main control surface linked to the pilot's controls or to the structure in such a way as to produce aerodynamic forces that move, or help to move, the surface. Among the various forms are flying tabs, geared or servo tabs, and spring tabs.

- Power-assisted flight controls: Reversible flight control systems in which some means is provided, usually a hydraulic actuator, to apply force to a control surface in addition to that supplied by the pilot to enable large surface deflections to be obtained at high speeds.

l. **Static air temperature:** The air temperature as would be measured by a temperature sensor not in motion with respect to that air. This temperature is also referred to in other documents as "outside air temperature," "true outside temperature," or "ambient temperature."

m. **Substantiated visual cues:** Ice accretion on a reference surface identified in the AFM that is observable by the flightcrew. (**NOTE**: Visual cues used to identify ice addressed in appendix C will differ from those used to identify large droplet ice.)

DISCUSSION OF THE PROPOSED RULE

The FAA has reviewed and accepted the recommendations that the IPHWG developed and ARAC approved. The FAA proposes to amend the current part 25 regulations in two areas:

1. Activation of the IPS

The first area addresses the possibility of the flightcrew failing to recognize that the airframe ice protection procedures should be initiated. The proposed rule would require a method of ice detection which enables activation of the airframe ice protection system (IPS) for the initial cycles and any subsequent cycles through:

- a primary ice detection system, automatic or manual; or
- visual cues for recognition of ice accretion on a specified surface, combined with an advisory ice detection system that alerts the flight crew; or
- identification of icing conditions, as defined by an appropriate static or total air temperature and visible moisture during all phases of flight, unless it can be substantiated that the ice protection system need not be operated during specific phases of flight;
- if the ice protection system operates in a cyclical manner: a system that automatically cycles the ice protection system, or an ice detection system that is effective for the initial activation of the ice protection system and subsequent cycles.

Each of these methods provides a clear means for addressing the safety concern of when the IPS must be activated.

2. Indication of Ice Accumulation Aft of the Airframe's Protected Areas

The second area of the proposed rule addresses the possibility of ice accumulations on the airplane that could lead to hazardous operating conditions if the airplane is allowed to stay in icing conditions. The rule would be limited to airplanes equipped with reversible flight controls in the pitch or roll axis, because these aircraft can be subject to uncommanded control surface deflections caused by ice accretions. The proposed rule would require a method to alert the crew that they should exit icing conditions. Two options would be:

- Visual cues must be defined that will enable the flightcrew to determine that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas, Or
- The airplane must be equipped with a system that alerts the flightcrew that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas.

These proposed requirements address the known problem of large droplet ice accretions aft of protected surfaces causing uncommanded pitch or roll control surface deflection that may result in loss of control of the airplane. The FAA will consider further rulemaking if improvements occur in ice detection system technologies.

The determination that the airplane is operating in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas could be based on:

- a measurement of ice accumulations on the airframe, or
- a measurement of supercooled liquid droplet diameters , or
- visual observation of ice accumulations on the airframe.

The intent of the proposed rule is to provide methods to detect when the airplane is experiencing these icing conditions. Therefore, forecast icing conditions are not to be considered when complying with this proposed rule.

FAA Advisory Material

In addition to the amendment proposed in this notice, the FAA has developed an Advisory Circular (AC) that provides guidance as to acceptable means of demonstrating compliance with this proposed rule. Comments on the proposed AC are requested by separate notice published elsewhere in this issue of the Federal Register.

Other Related Rulemaking

The FAA has proposed a new operations regulation that would revise 14 CFR part 121 and require actions similar to those in this proposed part 25 rule. The proposed operations rule would be applicable to airplanes with a maximum certificated takeoff weight less than 60,000 pounds. It would require either the installation of ice detection equipment, or changes to the Airplane Flight Manual to ensure timely activation of the ice protection system. For airplanes with reversible flight controls in the pitch and/or roll axis, the proposed operations rule would require that either :

- visual cues be defined that enable the flightcrew to determine that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas; or

- the airplane be equipped with an alert to notify the flightcrew that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas.

On being aware of ice accumulation aft of the airframe protected areas, the rule requires the pilot in command to take action to exit the conditions in which any ice accretion is occurring.

Paperwork Reduction Act

The Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)) requires that the FAA consider the impact of paperwork and other information collection burdens imposed on the public. We have determined that there are no new information collection requirements associated with this proposed rule.

International Compatibility

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with International Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent practicable. The FAA determined that there are no ICAO Standards and Recommended Practices that correspond to these proposed regulations.

Executive Order 12866 and DOT Regulatory Policies and Procedures

[APO is responsible for drafting the Regulatory Evaluation Summary.

Summary of the economic evaluation prepared by APO will be inserted here.]

Economic Evaluation, Regulatory Flexibility Determination, International Trade Impact Assessment, and Unfunded Mandates Assessment

Proposed changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency propose or adopt a regulation only upon a determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act (19 U.S.C. section 2531-2533) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, this Trade Act also requires agencies to consider international standards and, where appropriate, use them as the basis of U.S. standards. And fourth, the Unfunded Mandates Reform Act of 1995 requires agencies to prepare a written assessment of the costs, benefits and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local or tribal governments, in the aggregate, or by the private sector, of $100 million or more annually (adjusted for inflation.)

In conducting these analyses, FAA has determined this rule 1) has benefits which do justify its costs, is not a "significant regulatory action" as defined in the Executive Order and is "significant" as defined in DOT's Regulatory Policies and Procedures; 2) will not have a significant impact on a substantial number of small entities; 3) reduces barriers to international trade; and 4) does not impose an unfunded mandate on state, local, or tribal governments, or on the private sector. These analyses, available in the docket, are summarized below.

Regulatory Flexibility Act

The Regulatory Flexibility Act (RFA) of 1980, (5 U.S.C. 601 et seq.) directs the FAA to fit regulatory requirements to the scale of the business, organizations, and governmental jurisdictions subject to the regulation. We are required whether a proposed or final action will have a significant impact on a substantial number of "small entities" as defined by the Act. If we find that the action will have a significant impact, we must do a "regulatory flexibility analysis."

International Trade

The Trade Agreement Act of 1979 prohibits Federal agencies from engaging in any standards or related activity that create unnecessary obstacles to the foreign commerce of the United States. Legitimate domestic objectives, such as safety, are not considered unnecessary obstacles. The statute also requires consideration of international standards and where appropriate, that they be the basis for U.S. standards. In addition, consistent with the Administration's belief in the general superiority and desirability of free trade, it is the policy of the Administration to remove or diminish, to the extent feasible, barriers to international trade, including both barriers affecting the export of American goods and services to foreign countries and barriers affecting the import of foreign goods and services to into the U.S.

In accordance with the above statute and policy, the FAA has assessed the potential effect of this proposed and has determined that it would have only a domestic impact and therefore no affect on any trade-sensitive activity.

Regulations Affecting Interstate Aviation in Alaska

Section 1205 of the FAA Reauthorization Act of 1996 (110 Stat. 3213) requires the Administrator, when modifying regulations in title 14 of the CFR in manner affecting interstate aviation in Alaska, to consider the extent to which Alaska is not served by transportation modes other than aviation, and to establish such regulatory distinctions as he or she considers appropriate. Because this proposed rule would apply to the certification of future designs of transport category airplanes and their subsequent operation, it could, if adopted, affect interstate aviation in Alaska. The FAA therefore specifically requests comments on whether there is justification for applying the proposed rule differently in interstate operations in Alaska.

Unfunded Mandates Reform Act

[APO is responsible for developing this analysis.]

The Unfunded Mandates reform Act of 1995 (2 U.S.C. §§ 1532-1538) requires the FAA to assess the effects of Federal Regulatory actions on state, local, and tribal governments, and on the private sector of proposed rules that contain a Federal intergovernmental or private sector mandate that exceeds $100 million in any one year. This action *[does or does not]* contain such a mandate.

Executive Order 13132, Federalism

The FAA has analyzed this proposed rule under the principles and criteria of Executive Order 13132, Federalism. We determined that this action would not have a substantial direct effect on the States, on the relationship between the national Government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, we determined that this notice of proposed rulemaking would not have federalism implications.

Plain Language

In response to the June 1, 1998 Presidential memorandum regarding the use of plain language, the FAA re-examined the writing style currently used in the development of regulations. The memorandum requires federal agencies to communicate clearly with the public. We are interested in your comments on whether the style of this document is clear, and in any other suggestions you might have to improve the clarity of FAA communications that affect you. You can get more information about the Presidential memorandum and the plain language initiative at http://www.plainlanguage.gov.

Environmental Analysis

FAA Order 1050.1D defines FAA actions that may be categorically excluded from preparation of a National Environmental Policy Act (NEPA) environmental impact statement. In accordance with FAA Order 1050.1D, appendix 4, paragraph 4(j), this proposed rulemaking action qualifies for a categorical exclusion.

Energy Impact

The energy impact of the notice has been assessed in accordance with the Energy Policy and Conservation Act (EPCA) Pub. L. 94-163, as amended (42 U.S.C. 6362) and FAA Order 1053.1. It has been determined that the notice is not a major regulatory action under the provisions of the EPCA.

List of Subjects in 14 CFR Part 121

Aircraft, Aviation safety, Reporting and record keeping requirements, Safety, Transportation.

The Proposed Amendment

In consideration of the foregoing, the Federal Aviation Administration proposes to amend part 25 of Title 14, Code of Federal Regulations, as follows:

PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

1. The authority citation for part 25 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701, 44702 and 44704

2. Add new paragraphs (e), (f), and (g) to § 25.1419 to read as follows:

§ 25.1419 Ice Protection.

* * * * *

(e) One of the following methods of icing detection must be provided to indicate when the airframe ice protection system must be activated:

(1) A primary ice detection system that automatically activates or alerts the flightcrew to activate the airframe ice protection system; or

(2) A definition of visual cues for recognition of ice accretion on a specified surface combined with an advisory ice detection system that alerts the flightcrew to activate the airframe ice protection system; or

(3) Identification of conditions conducive to airframe icing as defined by an appropriate static or total air temperature and visible moisture during all phases of flight,

unless it can be shown that the ice protection system need not be operated during specific phases of flight.

(f) If the ice protection system requires repeated cycling after initial activation:

(1) the airplane must be equipped with a system that automatically cycles the ice protection system, or

(2) an ice detection system must be provided to alert the flight crew each time the ice protection system must be cycled.

(g) Procedures for operation of the ice protection system must be established.

3. Add a new § 25.1420 to read as follows:

§ 25.1420 Exit large droplet conditions.

(a) For airplanes with reversible roll or pitch controls: if certification for flight in icing conditions is desired, one of the following must be provided to alert the flightcrew that they must exit icing conditions

(1) Substantiated visual cues that enable the flightcrew to determine that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas; or

(2) A system that alerts the flightcrew that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas.

(b) Procedures for exiting icing conditions must be established.

Issued in Washington, D.C., on

Aircraft Certification Service

U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

Subject: COMPLIANCE WITH ICING REQUIREMENTS OF §§ 25.1419(e), (f) and (g) And 25.1420	**Date:** Draft 05/3/01 **Initiated By:** ANM-110	**AC No: 25-XX** **Change:**

WORKING DRAFT -- NOT FOR PUBLIC RELEASE.

1. PURPOSE.

a. This Advisory Circular (AC) describes an acceptable means for showing compliance with the requirements of § 25.1419(e), (f) and (g), "Ice Protection," and § 25.1420, "Exit large droplet conditions," of Title 14, Code of Federal Regulations (14 CFR) part 25, commonly referred to as part 25 of the Federal Aviation Regulations (FAR). Part 25 contains the applicable certification requirements for transport category aircraft. The means of compliance described in this document are intended to provide guidance to supplement the engineering judgment that must form the basis of any compliance findings relative to the requirements of §§ 25.1419(e), (f) and (g) and 25.1420. Guidance includes considerations for :

- installing a primary ice detection system;
- developing a method to alert the flightcrew that the airframe ice protection system must be activated and revising the Airplane Flight Manual (AFM) concerning procedures for activating the airframe ice protection system; and
- a means for the flightcrew to determine that they must exit icing conditions.

b. The guidance provided in this document is directed to airplane manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration airplane type certification engineers and their designees.

c. Like all advisory circular material, this AC is not in itself mandatory, and does not constitute a regulation. It is issued to describe an acceptable means, but not the only means, for demonstrating compliance with the requirements for transport category airplanes. Terms such as "shall" and "must" are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described in this document is used. While these guidelines are not mandatory, they are derived from extensive Federal Aviation Administration and industry experience in determining compliance with the pertinent regulations.

d. This advisory circular does not change, create any additional, authorize changes in, or permit deviations from regulatory requirements.

2. APPLICABILITY. The guidance provided in this AC applies to certification of part 25 transport category airplanes for flight in icing conditions.

3. RELATED DOCUMENTS.

a. **Regulations contained in Title 14, Code of Federal Regulations (CFR).**

Section	Title
§ 25.1301	Equipment - Function and installation
§ 25.1309	Equipment, systems, and installations
§ 25.1316(b)	System lightning protection
§ 25.1321	Instruments Installation - Arrangement and visibility
§ 25.1322	Warning, caution, and advisory lights
§ 25.1333	Instrument systems
§ 25.1419	Ice protection
§ 25.1420	Exit large droplet conditions
§ 25.1585(a)(6)	Operating procedures
Appendix C to part 25	

b. **Advisory Circulars (AC).** The AC's listed below may be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, SVC-121.23, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785:

Number	Title and Date
AC 20-73	Aircraft Ice Protection, dated April 21, 1971.
AC 20-117A	Hazards Following Ground Deicing and Ground Operations in Conditions Conducive to Aircraft Icing, dated December 17, 1982.

AC 20-115B	Radio Technical Commission for Aeronautics, Inc. (RTCA) Document RTCA/DO-178B, dated January 11, 1993.
AC 21-16D	RTCA Document DO-160C, dated July 21, 1998.
AC 25-7A	Flight Test Guide for Certification of Transport Category Airplanes, dated March 31, 1998.
AC 25-11	Transport Category Airplane Electronic Display Systems, dated July 16, 1987
AC 25.1309-1A	System Design Analysis, dated June 21, 1988.
AC 25.1419-1	Certification of Transport Category Airplanes for Flight in Icing Conditions, dated August 18, 1999.

c. **Other FAA Documents:**

Number	Title
DOT/FAA/CT-88/8-1	"Aircraft Icing Handbook," issued March 1991, updated September 1993

d. **Industry Documents.** The following documents can be obtained from Radio Technical Commission for Aeronautics (RTCA), Inc., 1140 Connecticut Ave., NW, Suite 1020, Washington, DC 20036.

Number	Title
RTCA/DO-178B	Software Considerations in Airborne Systems and Equipment Certification
RTCA/DO160D	Environmental Conditions and Test Procedures for Airborne Equipment

4. DEFINITION OF TERMS. For the purposes of this AC, the following definitions should be used.

a. **Advisory ice detection system:** An advisory system annunciates the presence of icing conditions or ice accretion. The flightcrew is responsible for monitoring the icing conditions or ice accretion as defined in the AFM, typically using total air temperature and visible moisture criteria, visible ice accretion, or specific airframe ice accretion thickness, and activation by the flightcrew of the anti-icing or de-icing system(s) remains a requirement. The advisory system provides information to advise the flightcrew of the presence of ice accretion or icing conditions, but it can only be used in conjunction with other means to determine the need for, or timing of, activating the anti-icing or de-icing system.

b. **Airframe icing:** Ice accretions on portions of the airplane, with the exception of the propulsion system, on which supercooled liquid droplets may impinge.

c. **Anti-Icing:** The prevention of ice formation or accumulation on a protected surface, either:

- by evaporating the impinging water or
- by allowing it to run back and off the surface or freeze on non-critical areas.

d. **Automatic cycling mode:** A mode of operation of the airframe de-icing system that provides repetitive cycles without the need for the pilot to select each cycle. This is generally done with a timer, and there may be more than one timing mode.

e. **Deicing:** Removal or the process of removal of an ice accretion after it has formed on a surface.

f. **Irreversible flight controls:** All of the force required to move the pitch, roll, or yaw control surfaces is provided by hydraulic or electric actuators, the motion of which is controlled by signals from the flight deck controls. Loads generated at the control surfaces themselves are reacted against the actuator and its mounting and cannot be transmitted directly back to the flight deck controls.

g. **Large droplet conditions conducive to ice accumulation aft of the airframe's protected area:** Conditions containing a population of supercooled droplets sufficiently larger than those provided for in appendix C (of 14 CFR part 25) to cause ice accretions aft of the protected areas. The accumulation mechanism aft of the protected surface may be by direct impingement and accretion or delayed freezing of large droplets that impinge further forward. These conditions may be aircraft-dependent as a consequence of the geometry of the airfoil and the limits of protected areas.

h. **Monitored Surface:** The surface of concern regarding ice hazard (for example, the leading edge of the wing).

i. **Primary ice detection system:** The means used to determine when the IPS must be activated. The system annunciates the presence of ice accretion or icing conditions and may also provide information to other aircraft systems. A primary <u>automatic</u> system automatically activates the anti-icing or de-icing systems. With a primary <u>manual</u> system, the flightcrew activates the IPS upon indication from the system.

j. **Reference Surface:** The surface where an ice detection sensor is located or where a visual cue is located remotely from the surface of concern regarding ice hazard (for example, a propeller spinner).

k. **Reversible flight controls:** The flight deck controls are connected to the pitch, roll, or yaw control surfaces by direct mechanical linkages, cables, or push-pull rods such that pilot effort produces motion or force about the hinge line. Conversely, force or motion originating at the control surface (through aerodynamic loads, static imbalance, or trim tab inputs, for example) is transmitted back to flight deck controls.

(1) Aerodynamically boosted flight controls: Reversible flight control systems that employ a movable tab on the trailing edge of the main control surface linked to the pilot's controls or to the structure in such a way as to produce aerodynamic forces that move, or help to move, the surface. Among the various forms are flying tabs, geared or servo tabs, and spring tabs.

(2) Power-assisted flight controls: Reversible flight control systems in which some means is provided, usually a hydraulic actuator, to apply force to a control surface in addition to that supplied by the pilot to enable large surface deflections to be obtained at high speeds.

l. **Static air temperature:** The air temperature as would be measured by a temperature sensor not in motion with respect to that air. This temperature is also referred to in other documents as "outside air temperature," "true outside temperature," or "ambient temperature."

m. **Substantiated visual cues:** Ice accretion on a reference surface identified in the Airplane Flight Manual (AFM) that is observable by the flightcrew. (NOTE: Visual cues used to identify ice addressed in Appendix C will differ from those used to identify large droplet ice.)

NOTE: These definitions of terms are intended for use only with respect to §§ 25.1419(e),(f) and (g), and 25.1420.

5. COMPLIANCE WITH § 25.1419(e)(1) and (e)(2).

a. **Requirements of the Rule.** This section of the rule requires either a primary ice detection system, or substantiated visual cues and an advisory ice detection system, to alert the flightcrew that the airframe ice protection system must be activated.

(1) One of the following provides an acceptable means of compliance with § 25.1419(e)(1):

- A primary manual ice detection system that provides an alert that the airframe ice protection system must be activated, or

- A primary automatic ice detection system.

(2) Substantiated visual cues, in conjunction with an advisory ice detection system, is an acceptable means of compliance with § 25.1419(e)(2). The visual cues can

range from direct observation of ice accretions on the airplane's protected surfaces to observation of ice accretions on reference surfaces. Examples of visual means could be:

- accretions forming on the windshield wiper posts,
- accretions forming on propeller spinners,
- accretions forming on radomes,
- accretions on the protected surfaces

If accretions on the protected surfaces cannot be observed, consideration should be given to providing a reference surface which can be periodically de-iced to allow better observation of the rate of ice accretion.

(a) *Field of View.* The visual cue should be developed with the following considerations:

(i) Visual cues should be within the flightcrew's vision scan area while seated and performing their normal duties.

(ii) The visual cue should be visible during all modes of operation (day, night).

(b) Verification. During the certification process, the applicant should verify the ability of the crew to observe the visual cue and reference surface. The visual cue should not be dependent upon the location of the flightcrew's seats. The visual cue should be evaluated from the most adverse flightcrew seat locations in combination with the range of flightcrew heights. The visual cues should be visible from both the left and right seats. Consideration should be given to the difficulty of observing clear ice. If a reference surface is used, the applicant should validate that it correlates with ice accumulation on the airframe's protected areas. Such visual cues should be validated by testing in measured natural icing.

(3) The applicant should present an icing certification plan, as suggested by AC 25.1419-1, to the cognizant Aircraft Certification Office. The plan should include the ice detector system's compliance with §§ 25.1301, 25.1309, 25.1419, and any other applicable sections.

b. **System Performance when Installed.** The applicant should accomplish a droplet impingement analysis and/or tests to ensure that the ice detector is properly located. The detector and its installation should minimize nuisance warnings.

c. **System Safety Considerations.** The applicant should consult AC 25.1309-1A for guidance on compliance with § 25.1309. In accordance with the AC, the applicant should accomplish a functional hazard assessment to determine the hazard level associated with failure of the ice detection system. The unannunciated failure of a primary ice detection system is assumed to be a catastrophic failure condition, unless the characteristics of the airplane in icing conditions without activation of the airframe ice protection system(s) are demonstrated to result in a less severe hazard category. If visual cues are primary, failure of an advisory ice detection system is considered to be minor.

d. **Software and Hardware Qualification.** For guidance on hardware and software qualification, the applicant should consult RTCA/DO-178B, "Software Considerations in Airborne Systems and Equipment Certification," and RTCA/DO160D, "Environmental Conditions and Test Procedures for Airborne Equipment."

e. **Safe Operations in Icing Conditions.**

(1) Section 25.1419 requires that the applicant demonstrate that the airplane is able to operate safely in the icing conditions defined in Appendix C to part 25. The ice detection system should be shown to operate in the range of conditions defined by Appendix C.

(2) Section 25.1419 also requires a combination of tests and analysis to demonstrate the performance of the ice detector and the system as installed on the airplane. This could include icing tunnel and icing tanker tests to evaluate the ice detector performance. Also required are analysis and flight tests in measured natural atmospheric conditions to demonstrate satisfactory performance of the system as installed on the airplane. It should be demonstrated that the airplane can be safely operated with the ice accretions formed at the time the ice protection system becomes effective, following activation of the ice detector.

f. **Airplane Flight Manual (AFM).** The AFM should address the following:

(1) Operational use of the in-flight ice detection system and IPS and any limitations; and

(2) Failure indications and appropriate crew procedures.

(3) Procedures for deactivating the IPS

6. COMPLIANCE WITH § 25.1419(e)(3)

a. **Requirements of the Rule.** This section of the rule provides an alternative to the primary ice detection system and the visual cues plus advisory ice detection system as defined in paragraph (e)(1) and (2). This alternative requires the operation of the ice protection system when the airplane is in conditions conducive to airframe icing during all phases of flight. If the ice protection system requires repeated cycling, an automatic cycling system must be provided.

b. The temperature cue used in combination with visible moisture should consider static temperature variations due to local pressure variations on the airframe. A minimum temperature limitation may be required on some types of systems due to equipment temperature limitations (such as elastomer pneumatic de-ice boot systems).

c. If this provision is used, the flightcrew should be able to easily determine the static air temperature. A display of static air temperature or a placard can be provided showing corrections for temperature vs. air speed to the nearest degree Centigrade in the region of interest (i.e., around 0° C). Requiring the flightcrew to access hand-held charts or calculators in lieu of a placard is not an acceptable means.

d. The limitations section of the AFM should identify specific static or total air temperature and visible moisture conditions which must be considered as conditions conducive to airframe icing, and should specify the phases of flight in which the IPS must be operated when these conditions are encountered.

7. COMPLIANCE WITH § 25.1419(f)

a. **Requirements of the Rule.** This section requires that if the ice protection system requires repeated cycling after initial activation:

(1) the airplane must be equipped with a system that automatically cycles the ice protection system, or

(2) an ice detection system must be provided to alert the flight crew each time the ice protection system must be cycled.

Some examples of systems which automatically cycle the IPS are:

1. A system that senses ice accretion on a detector and correlates to ice accretion on a protected surface. This system then cycles the IPS at a predetermined condition.
2. A system which cycles the IPS based on the use of a timer. Such a system may have more than one cycling time.
3. A system that directly senses the ice thickness on a protected surface and cycles the IPS.

The common attribute of all these systems is that the pilot is not required to manually cycle the IPS after initial activation.

Some examples of an ice detection system which alerts the flight crew each time the ice protection system must be cycled could be the same as 1 and 3 above, except that the system alerts the crew each time the IPS must be manually cycled. A timer that does not have ice sensing capability cannot be used to meet this requirement.

b. **System Performance when Installed.** The applicant should accomplish a droplet impingement analysis and/or tests to ensure that the ice detector is properly located. The detector and its installation should minimize nuisance warnings.

c. **System Safety Considerations.** The applicant should consult AC 25.1309-1A for guidance on compliance with § 25.1309. In accordance with the AC, the applicant should accomplish a functional hazard assessment to determine the hazard level associated with failure of the ice detection system. If visual cues are not available to indicate repeated cycles of a manually cycled de-icing system, the ice detection system may become primary under § 25.1309. The unannunciated failure of a primary ice detection system is assumed to be a catastrophic failure condition, unless the characteristics of the airplane in icing conditions without activation of the ice protection system(s) are demonstrated to result in a less severe hazard category. If visual cues are primary, failure of an advisory ice detection system is considered to be minor.

d. **Hardware and Software Qualification.** For guidance on hardware and software qualification, the applicant should consult RTCA/DO-178B, "Software Considerations in Airborne Systems and Equipment Certification," and RTCA/DO160D, "Environmental Conditions and Test Procedures for Airborne Equipment."

8. COMPLIANCE WITH § 25.1419(g)

Procedures for operation of the IPS should be provided in the AFM as discussed in section 5 and 6 above. Information should be provided to indicate that a de-icing system should not be de-activated until the completion of an entire de-icing cycle after leaving icing conditions. An anti-icing system should not be de-activated before leaving icing conditions.

9. COMPLIANCE WITH § 25.1420

a. **Requirement of the Rule.** Section 25.1420 is applicable to aircraft equipped with reversible flight controls in either the pitch or roll axis. It requires that one of the following must be provided to alert the flight crew that they must exit icing conditions:

- Substantiated visual cues that enable the flightcrew to determine that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas; or
- A system that alerts the flightcrew that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas

b. **Acceptable Means of Determining if Airplane is Operating in Large Droplet Icing Conditions.** There are several acceptable means for determining that the airplane is operating in large droplet conditions conducive to ice accumulation aft of the airframe's protected area. These include:

(1) Direct or Remote Measurement on a Monitored Surface:

(a) *Placement of Detectors.*

(i) For direct measurement, ice detectors are fitted directly onto the surface to be monitored. The detectors sense the presence and/or the thickness of ice that is accumulating aft of the protected area. They are usually flush-mounted (integrated on or within the skin). The monitored surface may vary from a spot of approximately 1 square inch to several square inches or larger.

(ii) For remote measurement, the sensing element is not directly fitted onto the surface to be monitored. An optical means (e.g., infrared or laser devices) may be one means of compliance. The surface extent monitored by this system is usually larger than with direct measurements.

(b) *Ability to Sense Ice*. The applicant should demonstrate that the detector will perform its intended function.

(i) For direct measurement, an icing wind tunnel and/or a laboratory chamber may be used to evaluate the ability of the ice detector to detect ice.

(ii) For remote measurement, laboratory tests may be used to demonstrate the ability of the detector to detect ice on the monitored surface.

(c) *Detector Position.* The detector should be positioned such that it performs its intended function with considerations given to the following factors:

(i) accretion characteristics of the monitored surface,

(ii) sensitivity of the airfoil to ice accretions,

(iii) thermal characteristic of the installation with respect to the generation of heat (direct measurement only),

(iv) physical damage from foreign objects,

(v) early detection (response time),

(vi) not intrusive relative to ice accretion on the monitored surface (direct measurement only),

(vii) field of view relative to the monitored surface (remote measurement only),

(viii) obscuration due to atmospheric conditions (e.g. snow, clouds) (remote measurement only), and

(ix) any other appropriate factors.

(d) *Analysis and icing wind tunnels* may provide information for location of the detector. In addition, laboratory tests may provide information for location of the remote detector.

(2) Remote Measurement Correlated to Ice Accumulation on a Monitored Surface. One method that could be used would be to provide indication of the conditions by discriminating droplet sizes. This method could provide an indication of conditions beyond those for which the airplane has been demonstrated.

(a) *Acceptable Settings.* Unless other acceptable criteria can be established, the device should be set to provide an indication when conditions exceed those specified in Appendix C, assuming a Langmuir E distribution for 50µm MED droplets. (The definition of a Langmuir E distribution can be found in the FAA Technical Report DOT/FAA/CT-88/8-1, "Aircraft Icing Handbook" published March 1991, updated September 1993.) When the device detects conditions that exceed the Appendix C conditions, the "exit icing" signal should be activated.
Note: this paragraph may need revision in light of further information to be developed during task 2.

(b) *Component Qualification.* The component level certification should verify that the uninstalled device is capable of providing a reliable and repeatable signal. One method would be to perform testing in an icing tunnel. The droplet size distribution should bracket the signal point, with droplet distributions slightly below and slightly above the signal point. The test should be repeated at sufficient conditions of liquid water content and ambient temperature to ensure operation throughout the icing conditions defined by Appendix C (of 14 CFR part 25) and with droplet sizes up to 500 microns, or identify limitations as to the conditions where performance is degraded. The applicant must substantiate the acceptability of any equipment limitations.

(3) Visual Means. This means can range from direct observation of ice accretions aft of the airplane's protected surfaces to observation of ice accretions on reference surfaces. Examples of visual means that could indicate to the flightcrew that the airplane is operating in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas include observations of:

- accretions forming on unheated portions of side windows,

- accretions forming on the aft portions of propeller spinners,
- accretions forming on aft portions of radomes, and
- water splashing on the windshields at static temperatures below freezing

(a) *Field of View.* The visual cue should be developed with the following considerations:

(i) Visual cues should be within the flightcrew's vision scan area while seated and performing their normal duties.

(ii) The visual cue should be visible during all modes of operation (day, night).

(b) *Verification.* During the certification process, the applicant should verify the ability of the crew to observe the visual cue and reference surface. The visual cue should not be dependent upon the location of the flightcrew's seats. The visual cue should be evaluated from the most adverse flightcrew seat locations in combination with the range of flightcrew heights, within the approved range of eye reference point locations, if available. The visual cues should be visible from both the left and right seats. Consideration should be given to the difficulty of observing clear ice. If a reference surface is used, the applicant should validate that it correlates with conditions conducive to ice accumulation aft of the airframe's protected areas. Validation of the visual cues may be accomplished by testing in measured natural icing or simulated large droplet icing behind a calibrated water tanker aircraft. However, the low probability of finding conditions conducive to ice accumulation aft of the protected areas may make natural icing flight tests impractical.

c. **System Safety Considerations.** The applicant should consult AC 25.1309-1A for guidance on compliance with §§ 25.1309.

(1) <u>Hazard classification</u>. The following is a qualitative analysis that may be used for determining the hazard classification for compliance with this part 25 regulation. Not all encounters with large droplet icing result in a catastrophic event. While definitive statistics are not available, given the volume of aircraft operations and reported incidents that did not result in a catastrophe, a factor of approximately 1 in 100 is a reasonable assumption of the probability of a catastrophic event, if an airplane encounters large droplet conditions conducive to ice accumulation aft of the airframe's protected areas. Based on the above assumption, the hazard classification of an unannunciated encounter with "large droplet conditions conducive to ice accumulation aft of the airframe's protected areas" may be considered as *severe major* in accordance with AC 25.1309-1A.

(2) <u>Frequency of occurrence</u>. The icing conditions described in Appendix C were designed to include 99 percent of the icing conditions. Evaluation of icing data has indicated that the probability of encountering icing outside of Appendix C droplet

conditions is on the order of 10^{-2}. The applicant may assume this probability for encountering the large droplet conditions conducive to ice accumulation aft of the airframe's protected areas. It should be considered as an average probability throughout the flight.

(3) Numerical safety analysis. For the purposes of a numerical safety analysis, the applicant may combine the probability of equipment failure with the probability, defined above, of encountering large droplet conditions conducive to ice accumulation aft of the airframe's protected areas. Therefore, if the applicant uses the above qualitative analysis for the hazard classification and the above probability of encountering the specified large droplet conditions (10^{-2}), it follows that the probability of an unannunciated equipment failure should be less than 10^{-5}.

d. **System Performance when Installed.**

(1) The ice detector system installed for compliance with § 25.1420 is intended to detect ice that forms due to large supercooled droplets that exceed Appendix C. Flight tests in measured natural icing conditions (required by § 25.1419) should be conducted to ensure that the system does not produce nuisance warnings when operating in conditions defined by Appendix C.

(2) The low probability of finding, for testing purposes, conditions conducive to ice accumulation aft of the protected areas, may make natural icing flight tests impractical as a means of demonstrating the system functions in conditions that exceed Appendix C. The applicant may use flight tests of the airplane under simulated icing conditions (icing tanker) or icing wind tunnel tests of a representative airfoil section to demonstrate the proper functioning of the system and to correlate the signals provided by the detectors and the actual ice accretion on the surface.

NOTE: The measured natural icing flight tests required by § 25.1419 are only applicable for conditions that are defined by Appendix C.

e. **Hardware and Software Qualification.** For guidance on hardware and software qualification, the applicant should consult RTCA/DO-178B, "Software Considerations in Airborne Systems and Equipment Certification," and RTCA/DO160D, "Environmental Conditions and Test Procedures for Airborne Equipment."

f. **Airplane Flight Manual**

(1) For ice detector systems, the AFM should address:

- operational use of the ice detection system and any limitations of the system; and
- failure indications and associated crew procedures.

(2) For visual means of compliance, the AFM should contain procedures that describe the visual means used to indicate that the airplane is operating in large droplet conditions that are conducive to ice accumulation aft of the airframe's protected areas.

(3) The following are acceptable AFM changes regarding actions the flightcrew should take after there is an indication of ice aft of the protected areas. Changes to the Limitations Section of the AFM must be approved by the FAA.

(a) Revise the Limitations Section of the FAA-approved AFM to require the pilot in command to immediately take action to exit the conditions where ice accretion is occurring, unless in the opinion of the pilot-in-command, it is necessary to delay such action in the interest of safety.

(b) Revise the Normal Procedures Section of the FAA-approved AFM to include the following:

- In order to avoid extended exposure to flight conditions that result in ice accumulations aft of the protected areas, the pilot in command must immediately take action to exit the conditions in which any ice accretion is occurring, unless in the opinion of the pilot in command, it is necessary to delay such action in the interest of safety.
- Avoid abrupt and excessive maneuvering that may exacerbate control difficulties.
- Do not engage the autopilot.
- If the autopilot is engaged, hold the control wheel firmly and disengage the autopilot.
- If an unusual roll response or uncommanded roll control movement is observed, smoothly but positively reduce the angle-of-attack.
- Do not extend flaps during extended operation in icing conditions. Operation with flaps extended can result in the possibility of ice forming on the upper surface further aft on the wing than normal, possibly aft of the protected area.
- If the flaps are extended, do not retract them until the airframe is clear of

ice.

- Report these weather conditions to Air Traffic Control.

- Maintain airspeed awareness and follow minimum speed guidelines per Airplane Flight Manual procedures, including a nose down attitude, if required, to maintain an acceptable airspeed.

Continue to follow these procedures until it can be determined that there are no ice accretions aft of the protected surface.

Transport Airplane Directorate
Aircraft Certification Service